Surgical Stapling: Principles and Precautions

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To Staple or To Sew?

Surgical staplers facilitate gastrointestinal surgery by rapidly closing or anastomosing bowel. Some anastomoses (e.g., choledochojejunostomy) are best done by hand. For other purposes, such as joining colon to a rectal remnant after a low anterior resection, stapling is easier and faster, or it creates a more consistent anastomosis in an inaccessible location. For most procedures, however, the choice is up to the surgeon. The advantages and disadvantages of various techniques are pointed out throughout this volume in the appropriate chapters.

Stapled anastomoses, when constructed with proper technique, are no better and no worse than those done with sutures. Stapling has the disadvantage of increased expense but the advantage of speed: A stapled anastomosis can generally be completed within 2–5 min, which is a significant benefit in the poor-risk patient who is critically ill and who may be undergoing an emergency operation. Even with the availability of skilled anesthesiologists expert in the physiologic support of desperately ill patients, there is indubitably an advantage to completing the operation speedily.

Stapled anastomoses cannot be expected to succeed under conditions that would make construction of a sutured anastomosis dangerous. There is no evidence that staples are safer than sutures, for instance, in the presence of advanced peritonitis or poor tissue perfusion.

Whereas sutures can be inserted and tied to appropriate tension to approximate but not strangulate a wide range of tissue thicknesses, staplers are much less tolerant. The stapler must be matched to the task and the tissue thickness (see below). In some situations (e.g., stricturoplasty for Crohn disease), the bowel may be too thick and diseased to staple accurately.

There are occasional, though rare, instances in which the exposure does not allow enough room to insert a stapling instrument into a body cavity. If this is the case, do not apply traction to the tissues to bring them within stapler range.

Characteristics of Staples

Modern gastrointestinal staplers are designed to preserve the viability of the tissues distal to the staple line. This is analogous to the "approximate but do not strangulate" principle used when a bowel anastomosis is hand sewn. Figure 5.1a, b shows how two common staples sizes are designed to enter the tissue straight and then bend into a B configuration. This allows blood to flow through the staple line. If staple size and tissue thickness are appropriately matched, one sees blood oozing through the staple line. Occasionally a figure-of-eight suture of fine PDS must be inserted to stop a small bleeder, particularly when the stomach is being stapled. This technique is contraindicated if the tissues are so thick; compression by the stapling device is likely to produce necrosis. On the other hand, if the tissues are so thin the staples cannot provide a firm approximation, bleeding and anastomotic leakage may occur.

There is some leeway when approximating tissues of varying thickness. Two standard staple sizes are available for the standard linear stapler. The 3.5 mm staple is 3.5 mm in leg length and 4.0 mm wide across the base. The 4.8 mm staple also is 4.0 mm wide across the base, but its leg length is 4.8 mm. The 3.5 mm stapler achieves a closed size of 1.5 mm, and the 4.8 mm stapler closes to 2 mm. For some staplers, the smaller (3.5 mm) cartridge is blue and the larger (4.8 mm) cartridge is green, hence the mnemonic "little boy blue and the jolly green giant." As a general rule, the 3.5 mm cartridge

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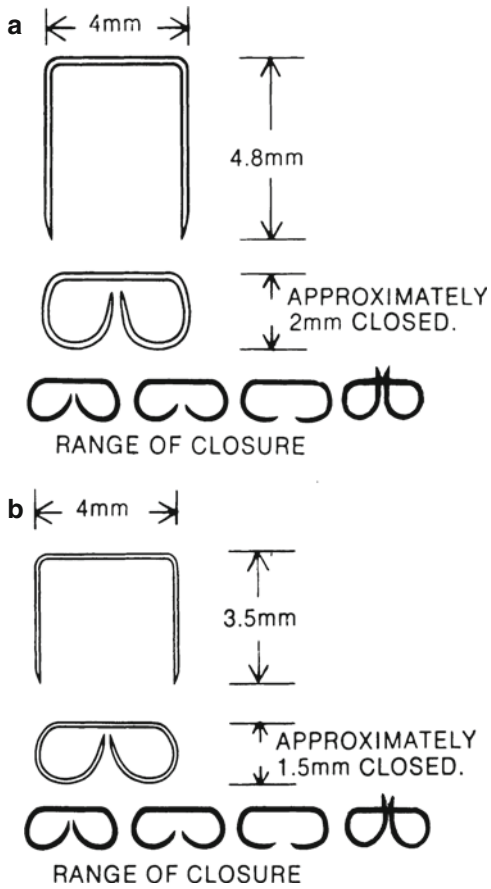


Fig. 5.1

is appropriate for most tasks. The 4.8 mm cartridge is used for thicker tissues, such as the stomach. Some stapling devices are continuously variable within this range, and the thickness may be tested with a gauge and then dialed in. Become familiar with the particular stapling devices used in your operating room and learn their operating characteristics.

The endoscopic linear cutting stapler compresses tissues to a thickness of approximately 1.75 mm.

Stapling in Inversion

The circular stapler and the linear cutting stapler create inverted staple lines that mimic the equivalent hand-sutured anastomosis. In many situations, both inverted and everted staple lines are created, as illustrated by the completed functional end-to-end anastomosis shown in Fig. 5.2. Here a linear cutting stapler was used to create the first (inverting) staple line, which brought the two segments of the colon into side-to-side alignment. A single stitch at the apex of this suture line helps provide mechanical stability. Three applications of a linear stapler have been used to close the open ends of bowel in an everting fashion.

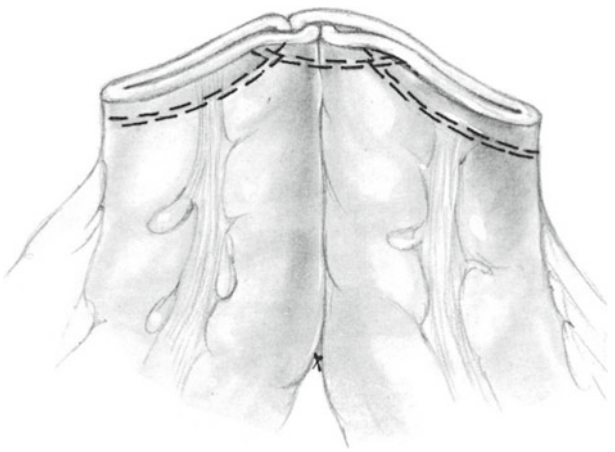


Fig. 5.2

Stapling in Eversion

Everted staple lines are commonly created when the linear stapler is used to complete an anastomosis or to close the end of a piece of bowel. Even when tissues are stapled in eversion, with mucosa facing mucosa, satisfactory healing takes place. This is in contrast to sutured everting anastomoses, which are generally weaker than inverting anastomoses.

Stapling Devices Used for Gastrointestinal Tract Anastomosis

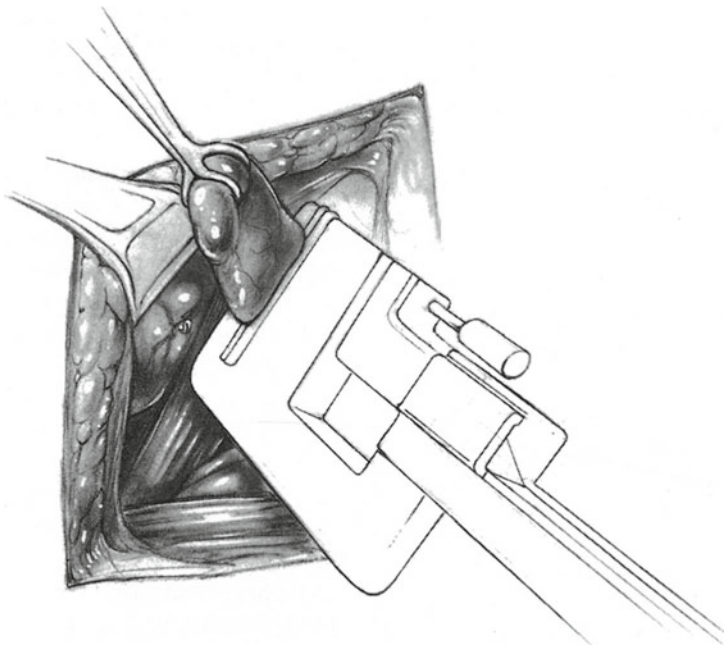
Linear Stapling Devices

The 55 mm linear stapler applies a doubled staggered row of staples approximately 55 mm long; similarly, the 90 mm linear stapler applies a doubled staggered row about 90 mm long. There is also a 30 mm stapler that is occasionally useful for extremely short suture lines.

Each device may be used with 3.5- or 4.8-mm staples, according to the principles described above. These devices are used to approximate the walls of the stomach or intestine in an everting fashion. They find application in closure of the duodenal stump, the gastric pouch during gastrectomy, and the end of the colon when a side-to-end coloproctostomy is performed.

Linear staplers use an aligning pin to ensure that the stapler cartridge meets the anvil accurately. This limits the length of bowel that can be stapled to a length that can be contained between the closed end of the device and the pin. For this reason, it is easier to use a cutting linear stapler (described below) when a long staple line must be produced. Figure 5.3 shows a linear stapler being used to close a Zenker's diverticulum prior to excision. Note that the tissue to be stapled is comfortably centered between the closed end

Fig. 5.3



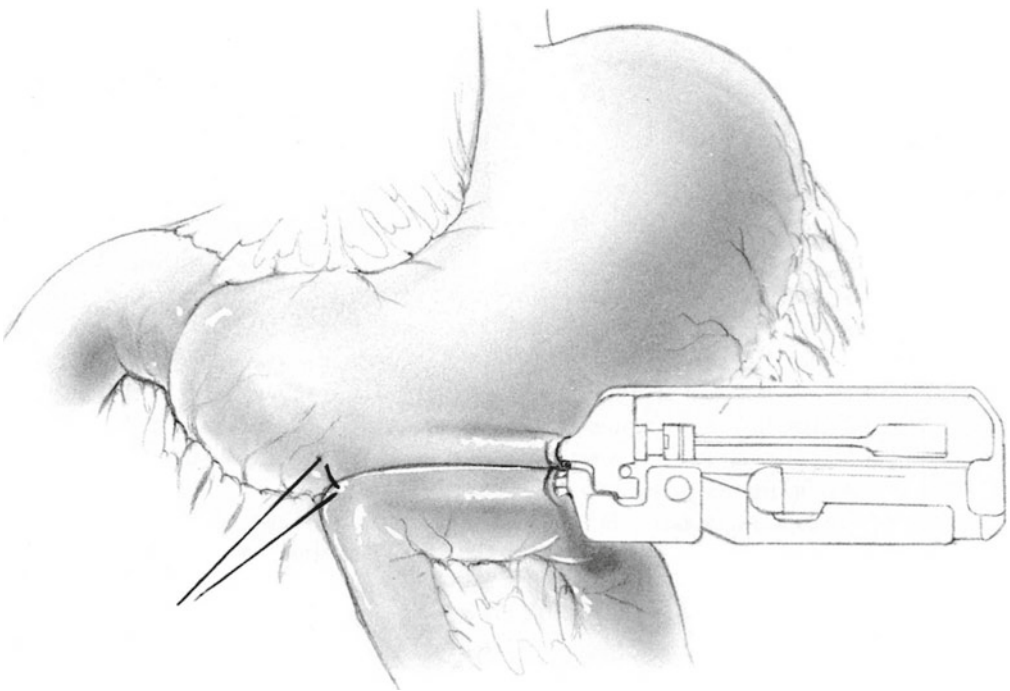


Fig. 5.4

of the stapler and the pin and that the stapler is longer than the desired staple line.

Linear Cutting Stapling Device

The linear cutting stapling device creates a stapled anastomosis with the tissues in inversion. It applies two double staggered rows of staples, while the knife in its assembly divides the tissue between the two double rows. It is used for side-to-side anastomoses (e.g., with gastrojejunostomy) and "functional end-to-end" anastomoses. It may also be used to divide the bowel prior to anastomosis. Figure 5.4 shows a linear cutting stapling device being used to join the stomach to the jejunum during a gastrojejunostomy.

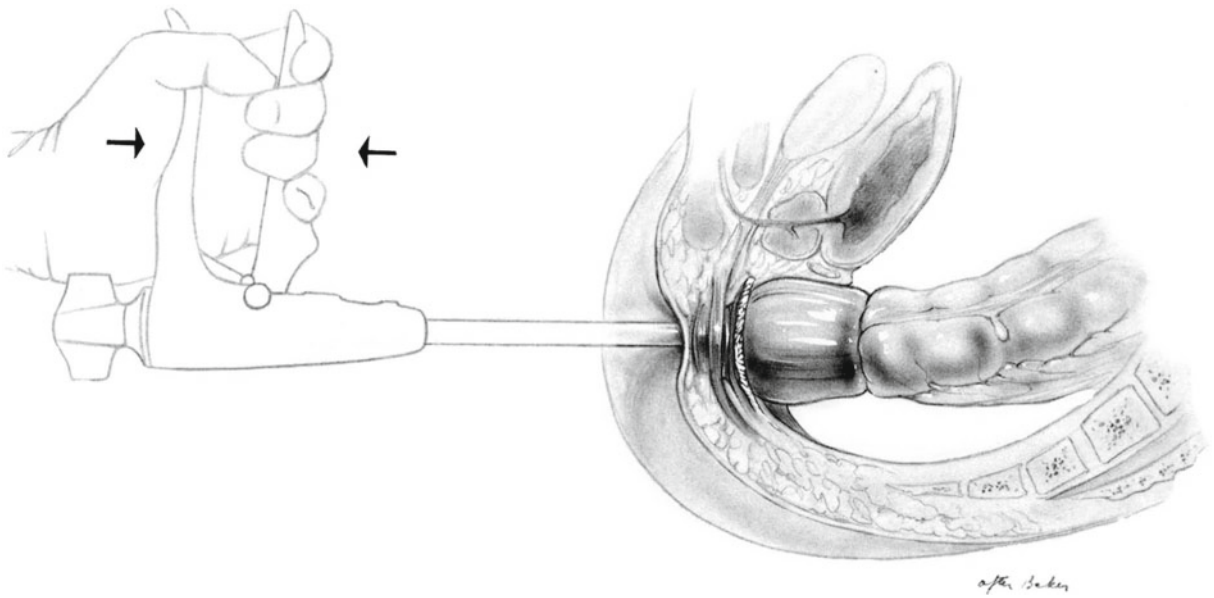


Fig. 5.5

Circular Stapling Device

The circular stapling device utilizes a circular anvil, a circular staple cartridge, and a circular knife to produce a double staggered row of staples that approximate two tubular structures in inversion while the knife cuts the tissue just inside the staple line. This creates an end-to-end anastomosis with a lumen ranging from 12 to 24 mm depending on the size of the device. The smaller sizes are rarely used. This stapler compresses tissues to a thickness of approximately 2.0 mm. Some circular stapling devices allow the surgeon to adjust the thickness within a range of 1.0–2.5 mm. When the device is inserted through the anal canal, it is ideally suited for a low colorectal anastomosis (Fig. 5.5). The circular stapler has also been used successfully for esophageal and gastroduodenal anastomoses.

Causes of Failure Following Stapled Anastomosis

Quality of the Tissues

The blood supply of the bowel to be anastomosed must be vigorous when staples are used, just as it must be for suturing. *Bowel that is not fit for suturing is not suitable for stapling*. Do not let the ease of inserting staples impair good judgment about the adequacy of tissue perfusion in the vicinity of any staple line. Always think of the blood supply.

When the linear cutting stapler is used to anastomose the jejunum to the back wall of a gastric pouch (see Fig. 33.44), at least 2.0–2.5 cm of gastric wall should be left between the linear cutting staple line and the closed end of the gastric pouch. This avoids a narrow ischemic strip of stomach and anastomotic failure.

Excessive compression of thickened tissues (e.g., gastric wall hypertrophied by chronic obstruction to a thickness of 6–8 mm) may produce a linear tear in the serosa adjacent to the stapling device. Seeing this, the surgeon should invert the staple line with a layer of seromuscular Lembert sutures; otherwise, the staple line should be excised and the closure accomplished entirely with sutures. Although tissue thickness rarely is a contraindication to the use of staples, failure by the surgeon to identify those cases in which the tissues are unsuitable for reliance on stapling may lead to serious complications.

Linear tension that exerts a distracting force against a sutured anastomosis certainly is detrimental. This tension is even more undesirable in the stapled anastomosis. One should assume that the fine wire in the staples tends to cut through tissues more readily than sutures, producing a leaking anastomosis. Reinforce points of expected tension (e.g., apex of a linear cutting staple line) with sutures.

Instrument Failure

The linear cutting stapling instrument may be misaligned, especially if it has been dropped on a ceramic floor and the two forks of the instrument diverge instead of remaining parallel. In this case the increased distance between the cartridge and the anvil prevents the staples at the distal end of the instrument from closing properly. As a precaution, *check the staple formation following completion of each anastomosis*.

In addition, when a reusable stapling device is used frequently, it should be test-fired once a month on a latex drain or a sheet of plastic to verify proper B formation (Fig. 5.1).

Partial failure of the knife assembly in the linear cutting stapling instrument occurs on rare occasions. When this happens the scalpel fails to make a complete incision between the two double rows of staples. If it is not detected by careful inspection, the resulting anastomosis has an extremely narrow lumen.

Complete failure of the staple cartridge to discharge staples has been known to happen. An inattentive surgeon may not notice it, as pressure alone may hold the bowel walls in apposition temporarily. A cartridge also fails to discharge staples if it has been spent and not replaced by a fresh cartridge before *each* application of the instrument.

Failure to wipe the excess spent staples from the anvil before inserting a fresh cartridge may result in poor apposition and difficult cutting. Check it before applying the stapler.

Human Error/Judgment

Do not place a staple line so it includes the mesentery of the bowel, as it may result in bleeding or intramural hematoma formation. Similarly, do not include mesenteric fat between the seromuscular layers of an anastomosis. Whenever the linear cutting stapling device is used on the gastric wall, carefully inspect the staple line for gastric bleeding. Transfix bleeding points with absorbable sutures. Occasionally an entire staple line in the stomach bleeds excessively. If it does, oversew the entire line with absorbable sutures inserted in the lumen of the stomach. Although it is preferable to insert sutures superficial to the staple line, there may not be sufficient tissue beyond the staples to accomplish it. On such occasions we have not had complications when 4-0 PG atraumatic sutures were inserted in the lumen of a linear cutting stapled anastomosis and were passed deep to the staples. These sutures must be tied with excessive tension. We have not observed significant bleeding following stapling in organs other than stomach. Minor bleeding may be controlled by cautious use of electrocautery.

When an excessive amount of tissue is bunched up in the crotch of the linear cutting stapler, firing the knife assembly may fail to incise the bowel between the two double rows of staples because the knife blade cannot penetrate the compressed tissue. As a result there is narrowing or absence of an anastomotic lumen. Every linear cutting staple line must be inspected for completeness and hemostasis upon removing the instrument. If the incision between the staple lines has not been made by the stapler knife assembly, it should be accomplished with straight scissors. Although this type of stapler failure is rare, its possibility should not be overlooked.

Multiple Allis clamps should be applied to the walls of the intestine included in a linear staple line. This prevents the bowel from retracting from the jaws of the instrument as the tissue is being compressed. If the tissue should retract from the jaws of the instrument, obviously the stapled closure would fail.

If an anastomosis constructed by the stapling technique has a lumen that is too small, the lumen probably cannot dilate following the passage of stool or food as much as it would if interrupted sutures had been used. If a stapled stoma is made too small, the two staggered rows of staples may keep it that way permanently after the anastomosis has been constructed. Consequently, more attention should be paid to the size of the lumen when constructing a stapled anastomosis than when constructing one by sutures.

Avoid making a false intramural passage when inserting the forks of the cutting linear stapler into stab wounds of the intestine or stomach, as it would prevent formation of a proper anastomosis. Place each fork accurately in the lumen of the intestine or the stomach.

The segments of the bowel should be in a relaxed position when a stapling device is applied to them. If excessive tension is applied while the stapler is being fired, the tissue may be too thin for proper purchase by the staples.

Special Precautions

After completing a stapled anastomosis, always inspect the entire circumference meticulously to ascertain that each staple has been formed into an adequate B. Test the lumen by invaginating the bowel wall with the index finger. Any point at which two or more staple lines cross should be carefully checked for possible leakage. Inspect the serosa for possible cracks or tears. If there is any doubt about the integrity of a stapled anastomosis, oversew it with a layer of interrupted or continuous seromuscular Lembert sutures of 4-0 atraumatic PG. Although the need to oversew the staple line occurs in no more than 1–2 % of cases managed by a surgeon experienced in performing stapled anastomoses, oversewing can be an essential step in preventing leaks in some situations.

During the last step of a functional end-to-end anastomosis, the defect is closed with a linear stapling device. If the first two stapling lines (Fig. 5.6) are kept in perfect apposition during this maneuver, six rows of staples can be seen to come together at one point after the linear stapler is fired. We believe that such a point is weak and permits development of an anastomotic leak because the presence of many staples and excess tissue in one spot results in failure to close properly. Occasionally this situation is seen in the operating room when carefully inspecting the completed anastomosis. To prevent this weak point, we have modified our technique by deliberately avoiding perfect apposition of the first two staple

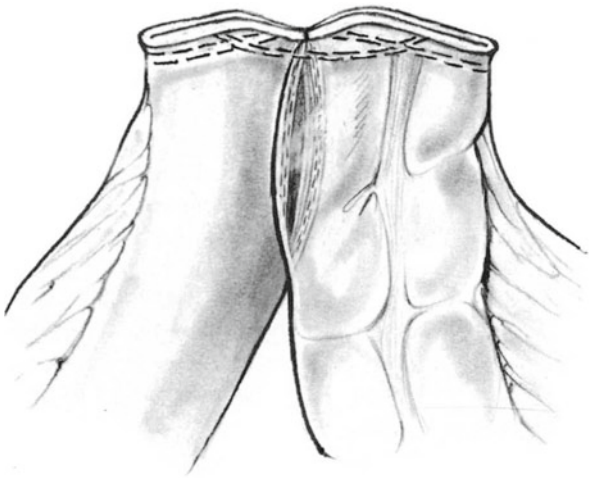


Fig. 5.6

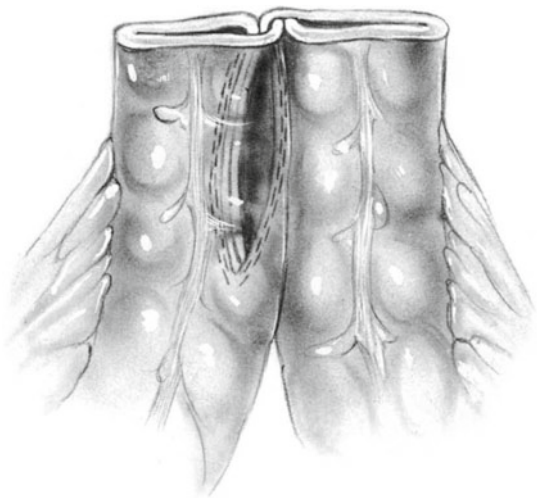


Fig. 5.7

lines to achieve more security (Fig. 5.7). A better way to avoid this problem is to use our modification of the functional end-to-end anastomosis, as illustrated in Figs. 51.35, 51.36, 51.37, and 51.38.

The many possible technical pitfalls of stapled low colorectal anastomoses are described in Chap. 53. Inserting the circular stapler anvil into the colon or esophagus is a problem when the lumen is too narrow to accommodate the anvil's diameter. The problem may result from muscle spasm or the use of a cartridge that is too large. Forceful dilatation may tear the coat of the colon or dilate the bowel to the point where it is too thin to hold staples firmly. The smallest available cartridges may result in an inadequate stoma size and should be used with care.

Further Reading

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